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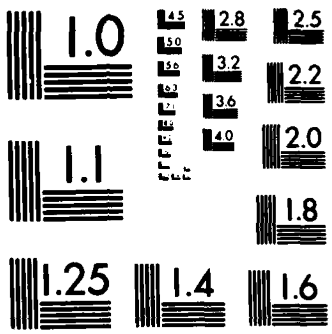

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AN AUGMENTED COMPUTERIZED READABILITY EDITING SYSTEM: FINAL REPORT

David E. Kieras

University of Michigan

Report No. 22 (FR-85/ONR-22)

June 30, 1985

This research was supported by the Personnel and Training Research Programs, Office of Naval Research, under Contract Number N00014-84-K-0729, Contract Authority Identification Number NR 667-513.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: TR-85/ONR-22	2. GOVT ACCESSION NO.: AD-A159491
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): An Augmented Computerized Readability Editing System: Final Report	5. TYPE OF REPORT & PERIOD COVERED: Technical Report June 30, 1985
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): David E. Kieras	8. CONTRACT OR GRANT NUMBER(s): N00014-84-K-0729
9. PERFORMING ORGANIZATION NAME AND ADDRESS: College of Engineering, University of Michigan, Ann Arbor, MI 48109	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: NR 667-513
11. CONTROLLING OFFICE NAME AND ADDRESS: Personnel and Training Research Programs, Office of Naval Research (Code 458), Arlington, VA 22217	12. REPORT DATE: June 30, 1985
	13. NUMBER OF PAGES: 10
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Readability; documentation; authoring systems

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is the final report of a research contract whose purpose is to develop a computer program that will assist technical writers to prepare more comprehensible material. The approach is as follows: (1) Computer programming techniques from artificial intelligence and cognitive modelling will be used to achieve more sophisticated processing of text than current

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S/N 0102-014-6601

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authoring aids provide. (2) Results and theory from research on comprehension will supply the rules for what constitutes comprehensible writing. This report summarizes the progress made in the development of a demonstration system of this type, empirical tests of its potential value, and work toward a full-scale prototype.

AN AUGMENTED COMPUTERIZED READABILITY EDITING SYSTEM:
FINAL REPORT

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ABSTRACT

This is the final report of a research contract whose purpose is to develop a computer program that will assist technical writers to prepare more comprehensible material. The approach is as follows: (1) Computer programming techniques from artificial intelligence and cognitive modelling will be used to achieve more sophisticated processing of text than current authoring aids provide. (2) Results and theory from research on comprehension will supply the rules for what constitutes comprehensible writing. This report summarizes the progress made in the development of a demonstration system of this type, empirical tests of its potential value, and work toward a full-scale prototype.

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AN AUGMENTED COMPUTERIZED READABILITY EDITING SYSTEM: FINAL REPORT

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This is the final report for a research contract concerned with developing an augmented version of the computerized readability editing system (CRES) developed by Peter Kincaid and associates of TAEG. This project is being continued under a new research contract. The purpose of this final report is to summarize progress achieved thus far on this project.

The goal of the project is to develop a computerized system that will assist the writers of technical text, such as equipment manuals and training materials, to prepare documents that are comprehensible to the typical reader. Such a comprehensibility system would be most suitable in an environment in which the variety of computerized authoring aids were already in use, such as word processing and computerized typesetting systems. The draft of a document would be fed into the comprehensibility system, and the output would be comments upon the draft pointing out where the typical reader will find the material hard to comprehend. The goals of this contract were first, to demonstrate the usefulness of such a system, and second, to demonstrate the basic technical feasibility of developing such a system. The new contract is concerned with developing a prototype version of the system and evaluating it with actual technical writers to determine whether this type of feedback is of actual value to the writers. If so, then implementing a field version of the comprehensibility system could then be considered.

Background

Current Systems

Two systems already exist that attempt to provide feedback to the writer concerning the quality of a document. The oldest of these is the writer's workbench package (WWB) (Cherry, 1982; McDonald, Frase, Gingrich, & Keenan, 1982). A more recent system is the CRES system (Kincaid, Aagard & O'Hara, 1980; Kincaid, Aagard, O'Hara, & Cottrell, 1981; Kincaid, Cottrell, Aagard, & Risley, 1981). Both CRES and WWB are intended to be used on a computer as part of a general word processing and document preparation package. After preparing a draft of a document, the writer feeds it into the system and obtains output about the

quality of the writing. The CRES system provides an annotated copy of the document. Specific problems are pointed out, and some global information, such as readability scores are provided. The specific feedback consists of several useful items. Sentences of excessive length are flagged along with the number of words in the sentence. The use of the passive voice is pointed out, along with strings of words that involve too many prepositions, which are often associated with awkward phrases. Simpler wording is suggested, such as use as a replacement for utilize.

The WWB system provides a large number of global statistical items to the writer, but seems to be relatively weak on providing exact criticism of specific problems in the text. This basically statistical approach appears also in another program that compares the statistics for a document with those for one that has been chosen to represent good documents of that type. For example, the program will inform the writer of an interoffice memo that the memo has more uses of the passive voice than a good interoffice memo. Another program flags some specific problems in a manner similar to the CRES system, but it does not appear to be as comprehensive.

Problems With Current Systems

A program that attempts to aid the writer in preparing comprehensible text will be valuable only to the extent that the criticisms and advice it offers actually reflect the ultimate goals of the writing process. The problems with both CRES and WWB is that they are based on ordinary writer's intuitions, many of which are actually either incorrect or misleading, when compared with what is actually known about comprehension of technical text. Another problem is that some of the more popular rules for clear writing are often unprincipled in basis, and so must use arbitrary cutoffs. For example, WWB and CRES will flag sentences of excessive length. But, how long does a sentence have to be before it is too long? The maximum acceptable length of a sentence is clearly a function of the syntactic complexity and the amount of information; neither one of these will necessarily be reflected in a single cutoff on the number of words in the sentence.

A second class of problems with current systems is that they perform little or no linguistic or semantic analysis of the input. That is, both CRES and WWB treat the input simply as strings in which there are certain simple patterns to be recognized. Neither system actually parses the sentence to discover its grammatical structure, nor do the systems consider the relationships between sentences. Thus both systems will deliver essentially the same output even if the sentences were fed into the program in reverse order. Of the current systems, only the EPISTLE system (Heidorn, Jensen, Miller, Byrd, &

Chodorow, 1982) actually parses the sentences, and so can comment on grammatical errors. However, at this time the EPISTLE system is primarily limited to processing individual sentences; the relations between sentences are not yet included in any comprehensive way.

To a great extent these limitations on CRES and WWB simply reflect the fact that they are both intended to be used on relatively small computers. Now that much more powerful computers are available, more sophisticated processing should be possible.

Project Approach and Goals

The approach taken in this project has two main components: First, the criticisms provided by the comprehensibility system will be based on what is known from research on comprehension concerning what actually makes text difficult to comprehend. Thus, the behavior of the system will not be a reflection of writer's intuitions, but rather will be based on scientific knowledge about what properties of text contribute to difficulties in comprehension.

Second, the system will be based on work in artificial intelligence and cognitive modelling that provides techniques and mechanisms for analyzing the content not only of individual sentences, but also of text, representing this content in an efficient and useful way, and examining it for comprehensibility problems.

Although neither artificial intelligence nor cognitive modelling has yet arrived at a truly comprehensive language processing system, in this limited domain it should be within the reach of present technology to develop a useful system. That is, since the readership for technical manuals and training materials is limited to readers with only low to moderate skill, the syntactic and semantic complexity of the material should definitely be limited in some way. A comprehensibility system with limited parsing and comprehension abilities can thus act as a filter to determine when the text is unduly complex. Thus, such a system does not have to be able to parse or comprehend everything it finds in the input; rather, it need only be able to understand everything that <u>should</u> be in the input. Because of this natural limitation on input complexity, implementing a useful comprehensibility system should be quite feasible with "off the shelf" techniques.

The specific goals of the project were as follows: the first goal was to determine whether the project appeared to be basically feasible and useful. This would be done by developing a demonstration version of the comprehensibility system using existing techniques, and conducting some experimental tests of

whether the type of feedback provided by the system would actually result in more usable documents. At the same time, a large scale review of the research literature on comprehension would be conducted in order to collect a set of rules for how comprehensible technical prose should be prepared. If both the experimental tests and the demonstration system were successful, then the next steps, now being conducted under the current project, would be to develop and evaluate an actual prototype of the system.

Work Accomplished

The work accomplished under this contract falls into three categories. A demonstration version of the comprehensibility system was constructed; Technical Report No. 17 summarizes this work, along with the basic rationale for systems of this type. The empirical demonstration of the value of the type of feedback that such a system could provide is described in Technical Report No. 20. The literature review covering possible comprehensibility rules appears as Technical Report No. 21. Some additional work, which will be described below, was done in preparation for the prototype development under the new contract.

The Demonstration System

The demonstration system was assembled quickly and simply by combining software components contained in cognitive simulation models developed under previous ONR contracts. An existing ATN parser (Kieras, 1983) and an existing production system interpreter (Kieras, 1982) were combined. The parser would analyze each individual sentence, and output a semantic structure for the sentence that was tagged with syntactic markers. A set of production rules would then examine this structure in the context of the previous sentences to determine whether any comprehensibility problems were present, and to determine the relationship of this sentence to the previous ones. Then the semantic content of the sentence would be added to the database for the previous sentences, and the system would proceed to read the next sentence.

As described in Kieras (1985a), this simple demonstration system was able to do relatively sophisticated processing, although its syntactic coverage was severely limited. For example, it could detect inconsistent terminology, and make suggestions on what the terminology should be in order to be consistent. It could detect when objects were referred to that had not been previously introduced. It applied a principled rule for when the sentence contained too much information, which corresponds to the customary ban on sentences that are too long. It could recognize when the topic of discussion had been changed, and distinguish appropriate from inappropriate uses of the passive voice.

Thus the demonstration system showed that considerable power to detect comprehensibility problems could be obtained in a very straightforward way using conventional techniques from cognitive modelling and artificial intelligence. However, being based on existing software that was originally developed for other purposes, this demonstration system was too clumsy and limited to be easily extended. During this project period, the key components of the system were rewritten in order to alleviate these problems for the development of the prototype system.

Experimental Demonstrations

A key question is whether such a comprehensibility system would actually be of value if it were implemented. This question could be partially answered, without the system actually being constructed, simply by hand-simulating the operation of the system, and determining whether the resulting document would be more comprehensible. Two experiments were done on the subject.

The experiments had two key features: First, a relatively realistic reading task was used, rather than the usual memory tests used in most comprehension research. The subjects had to make use of a simulated equipment manual in order to figure out how to operate an artificial piece of equipment. Second, rather than starting with a good version of the materials and then degrading it to obtain a bad version, a common approach in much comprehension research, a realistic version of the manual was prepared first, using a typical engineering documentation style, and then systematically improved. The improvement was made by hand-simulating the operation of the comprehensibility system. A set of rules for comprehensible writing were prepared and carefully applied to the original version of the simulated technical manual. These rules identified where there were comprehensibility problems of the same type that a feasible system could detect. Then the simulated manual was rewritten in response to the criticisms, and a second pass of the hand-simulated comprehensibility system was applied. This process was repeated until no more problems were detected, which required a total of five passes. Note that even simple rules, such as using consistent terminology, require a large amount of bookkeeping, suggesting that a computerized system would be extremely useful in carrying out this type of document evaluation automatically.

The improved version of the manual produced substantial performance improvements of several types. At least under some conditions, subjects with the good version were able to learn how to operate the device substantially faster than subjects with the original version of the manual. Subjects using the good version had less need to return to the manual to reread important sections. In a variety of ways, the good version subjects demonstrated a better understanding of the device that they were

operating. When the device malfunctioned, their statements about the nature of the problem were much more accurate, and had a greater tendency to be based on actual knowledge of the mechanism of the device. Another reflection of this better understanding was that good version subjects were able to devise more efficient procedures for operating the device.

These experiments are among the first to demonstrate performance effects of improvements in technical materials, where the nature of the improvements is well-defined and systematic. These results are described in Kieras (1985b), and were presented in an invited colloquium at Bell Laboratories, and to national scientific meetings.

Prototype Development

During this period, progress was made toward the development of a prototype version of the comprehensibility system that would have more power than the demonstration version of the system. The literature review was a critical part of this process. The goal of the literature review was to summarize what is known in the psycholinguistics literature that would be useful in the development of systems of this type. Approximately 170 journal articles were examined, and 59 rules for comprehensible writing were derived from this literature. The rules considered were limited to those that are technologically feasible to implement in a computerized comprehensibility evaluation system, such as the prototype system now being developed. The literature review appeared as Kieras and Dechert (1985).

During this period key components of the demonstration system were completely rewritten to be more efficient and to act as a better foundation for large scale upgrading of the system's power. The ATN interpreter was completely rewritten, and a set of tools were devised that take advantage of the user interface facilities on the Xerox 1108 LISP machine. This will make rapid development of more complex grammars much easier than was possible previously. The LUNAR grammar (Bates, 1978) was examined in some detail, and a determination made that the slightly different approach used in this project would be able to achieve comparable parsing power.

The new production system interpreter is still undergoing final development. The first version is already operational. This production system interpreter makes use of "data-flow" techniques, based on Forgy's (1979) work, to allow a production system to be executed at high speed. The goal in this development is to produce a highly efficient but very compact module that can be used in not only this project, but other ONR-sponsored projects. Under the new contract, these two components will be combined along with a more powerful grammar

and the expanded set of comprehensibility rules to produce the prototype system.

Problems Encountered

It should be noted that there were many problems of an administrative nature in this project. There were repeated administrative delays in the funding, and the funding cycle itself presented awkward problems for a university-based research and development program. The funding cycle did not overlap an academic year, making it extremely difficult to recruit post-doctoral personnel to work on the project while the Principal Investigator was at the University of Arizona. As of September, 1984, the Principal Investigator moved to the University of Michigan, where graduate students in artificial intelligence are available to work on the project. It is expected that this source of talent will minimize the effects of the funding cycle timing.

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